

How Plants Work: A Guide to Being Green *Teacher's Edition*



UNITED STATES
BOTANIC GARDEN



Welcome

to the United States Botanic Garden!

How Plants Work: A Guide to Being Green will help your students explore four Big Ideas relating to plants. Through their investigations, your students will discover the intriguing life, structural design, adaptability, and resourcefulness of plants.

The Big Ideas

Your students will investigate four Big Idea topics as they venture into the Conservatory. While trekking through the different habitats, your students will discover living examples of how plants work and see each Big Idea in action.

- 1. Are Plants Like Us?** – Explore the phenomenal things plants can do and how thoroughly man depends upon them. Use the provided family tree to trace familiar plants back to their ancestral roots.
- 2. A Puzzle of Plant Parts** – Discover the many forms plants take as a result of being adapted to unique environments.
- 3. Surviving Against the Odds** – Learn to appreciate the incredible variety of ways in which plants meet their daily challenges (e.g., battling predators, surviving drought, finding enough light, etc.).
- 4. Plant Multiplication** – Explore reproductive cycles for four recognized plant groups: ferns (vascular, spore-producing plants), mosses (non-vascular, spore producing plants), gymnosperms (cone-bearing plants), and angiosperms (flowering plants).



Getting Started

How Plants Work is not about creating a list of facts and figures. Instead, the intent is to challenge students to explore, think, and come up with their own questions and conclusions about how plants work and the various ways plants impact human life.

How to Use This Guide:

Each Big Idea area is explored in this guide by:

- introducing the topic;
- presenting activities that enable students to explore the Big Idea topic throughout the Conservatory;
- providing students with a detailed exploration of each Big Idea topic via a “Dig Deeper” section; and,
- concluding with remarks and discussion points to help students summarize and reflect on their Big Idea-related learning experience.

Guidelines for Managing Your Class Visit:

1. Depending on your use of the Journal, allow anywhere from one to three hours for your visit.
2. Divide students into four groups (each group gets a Big Idea) and assign a chaperone to each group.
3. Provide the class with an introduction into each of the Big Ideas using the included Introductory Lesson.



National Science Education Standards

- **NS.K-4.1 – SCIENCE AS INQUIRY**

As a result of their activities in grades K-4, all students should develop an understanding of scientific inquiry and abilities necessary to do scientific inquiry.

- **NS.5-8.1 – SCIENCE AS INQUIRY**

As a result of their activities in grades 5-8, all students should develop an understanding of scientific inquiry and abilities necessary to do scientific inquiry.

- **NS.K-4.3 – LIFE SCIENCE**

As a result of their activities in grades K-4, all students should develop an understanding of the characteristics of organisms, life cycles of organisms, and organisms and environments.

- **NS.5-8.3 – LIFE SCIENCE**

As a result of their activities in grades 5-8, all students should develop an understanding of structure and function in living systems, including reproduction and heredity, regulation and behavior, populations and ecosystems, and diversity and adaptations of organisms.

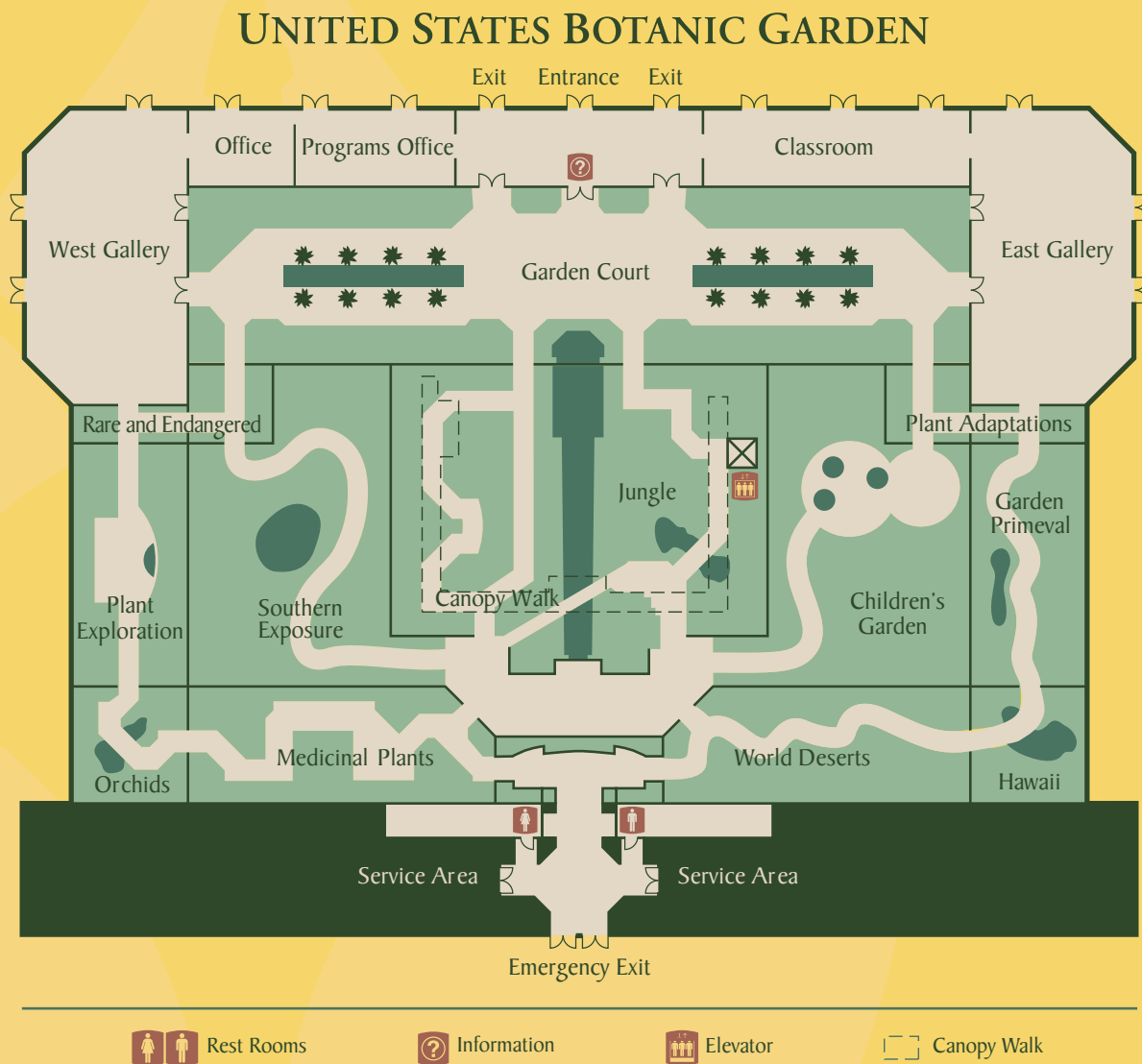
Have fun! The more fun your students have at the U.S. Botanic Garden, the more likely they are to be interested in “digging deeper” into the lives of plants.



How Plants Work: Introductory Lesson

Exploring the Conservatory

Using the map provided, guide your students quickly through the Conservatory to give them a sense of the layout. This should take approximately 15 minutes.



Big Ideas About Plants

1: Are Plants Like Us?

Plants are like humans because both need energy to survive. However, plants are different because they capture energy from the sun and make their own food.

Highlight: Learn that plants photosynthesize and make their own food and we don't.

2: A Puzzle of Plant Parts

Plants have a number of parts that work together to ensure the plant's survival.

Highlight: Point out different plant parts (e.g., stems, roots, seeds, flowers, etc.)

3: Surviving Against the Odds

Plants have evolved to look and function the way they do to thrive in local temperature, light, moisture, and soil conditions.

Highlight: Contrast the large dark green leaves in the Jungle with the tiny, light blue/green or no leaves in the desert; contrast the fat bottoms and fleshy, soft stems of cacti, which act as water tanks, to the drip tips of jungle plants that act as rain gutters to whisk the water away.

4: Plant Multiplication

To ensure species survival, plants, like humans, must reproduce and create offspring. Unlike humans, plants cannot travel to find their mates or places to live. Instead plants depend on wind, water, and other vectors, such as animals, to disperse their seeds, spores, and pollen.

Highlight: Have students use their Plant Family Tree, observe live plants, and discuss these four recognized plant groups (ferns, mosses [reproduction with spores and not seeds], gymnosperms [cone-bearing plants], and angiosperms [flower-bearing plants]).

Let's Get Started!

Becoming a Savvy Plant Sleuth!

If you have not already done so, have students break up into four groups, and assign each group a Big Idea. Students, guided by their chaperones, should complete the Student Discovery Journal activity relating to their assigned Big Idea section.

*Please remind students that we are a living museum, and to enjoy the plants **not** by touching, but by seeing. Upon returning to school, each group can share what they learned.*



Big Idea 1

Are Plants Like Us?

Do you really grow like a weed?

Student Objectives

Upon completing this Journal section, the student will be better able to:

1. Compare and contrast human and plant growth.
2. Use observational skills to develop hypotheses about plant growth and development.
3. Synthesize knowledge about plant growth and development.

Time Needed: 45 minutes

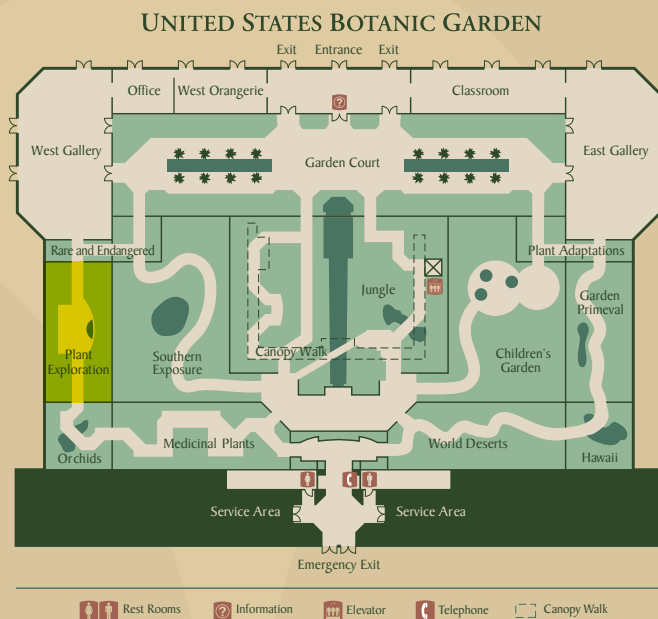
Exploring the Conservatory...

Think Tank Prompt:

Have your students select a partner. Consider the following: How are humans and plants the alike? How are they different? e.g., composed of cells; both grow; both need energy to function; plants capture energy from the sun and make their own food, while humans get energy from eating plants and animals; plants have cell walls and contain chloroplasts; etc. Have students share their thoughts on these questions before proceeding to Plant Exploration.

Become a Savvy Plant Sleuth!

Proceed into Plant Exploration.



Have students choose any plant in Plant Exploration and compare it to their partner. They should complete the activity in the Student Discovery Journal. This activity is designed to familiarize students with ideas like: Both humans and plants grow, but the ways we attain and metabolize energy are different.

List three things both the plant and your partner can do:

Examples: grow, use water, eat, sunbathe, etc.

List three things the plant can do that your partner cannot do:

Examples: make his/her own food, produce oxygen, make flowers, make perfume

List three things your partner can do that the plant cannot do:

Examples: walk around, talk, put on a sweater if it gets cold, sleep

Time permitting, have students share one item from each list with the rest of the students in their group.

Dig Deeper...

Tell your students they will have a chance to take on the role of a botanist by exploring the plants of the U. S. Botanic Garden and developing ideas about how plants use light, water, and nutrients. Student responses do not need to match the provided examples. This activity is designed to challenge students to express logical thought and explore scientific inquiry.

Take your students up the canopy walk in the Jungle. Have them observe several epiphytes (non-parasitic plants that grow on top of, or are attached to, other plants—e.g., bromeliads and orchids) during their trek. Students should choose one epiphyte to draw in their Journal. Why are some plants epiphytic?

Think Tank Prompt: How do these plants get light? How do they get water? How do they get nutrients? Focus student attention on the epiphytic orchids with root systems and epiphytic bromeliads.

Are Plants Like Us?
Do you really grow like a weed?

Exploring the Conservatory...
Follow your teacher or adult leader into Plant Exploration. For this activity, you will need a partner. Once you have chosen your partner, look around at all the different plants in Plant Exploration.

Choose a plant.
Which plant did you choose? _____
Now compare your plant to your partner.

THINK TANK!
How are humans and plants the same? How are they different?
While looking at your partner and your plant choice, answer the following questions in the space provided:

List three things both the plant and your partner can do:
(Example: eat)
1. _____ 2. _____ 3. _____

List three things the plant can do that your partner cannot do: (Example: make oxygen)
1. _____ 2. _____ 3. _____

List three things your partner can do that the plant cannot do: (Example: walk around)
1. _____ 2. _____ 3. _____

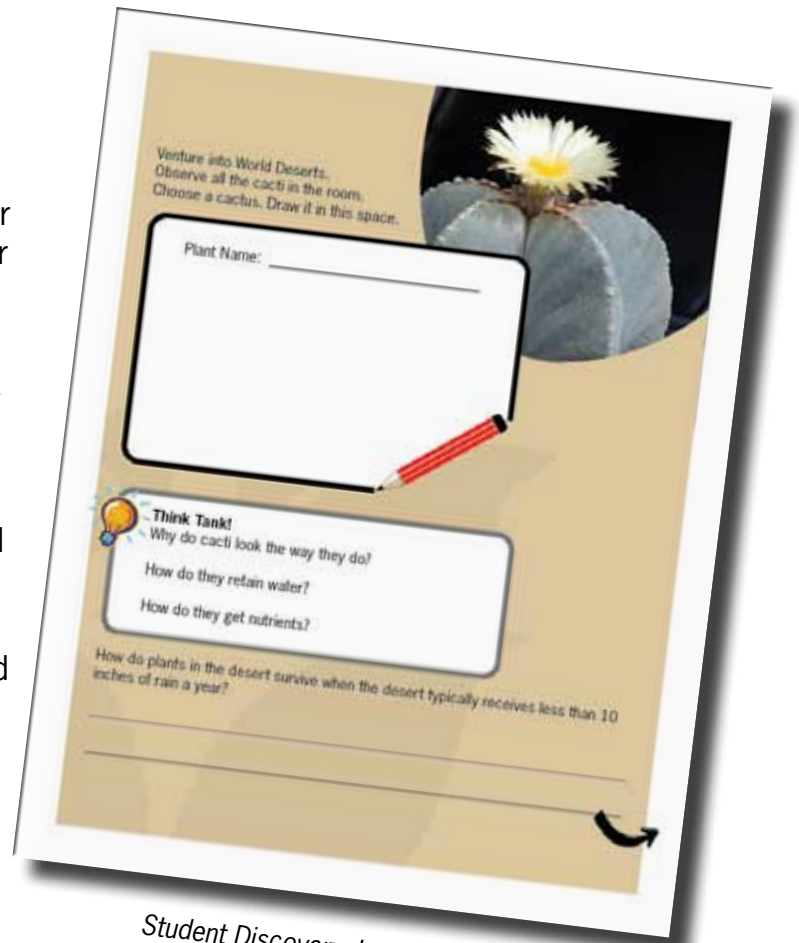
Dig Deeper ...
You be the botanist! Venture into the Jungle and climb up to the canopy. The U.S. Botanic Garden wants you to think about the ways that plants use light, water, and nutrients.

Student Discovery Journal page

Have students develop a hypothesis about how epiphytic plants use light, water, and nutrients. Samples include:

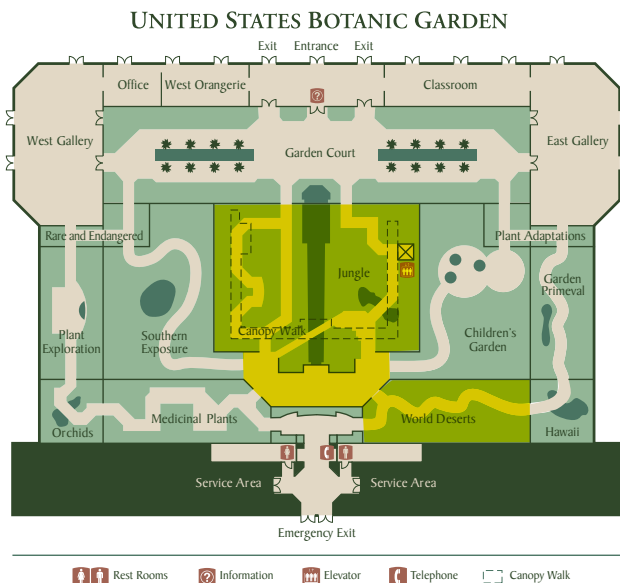
- Epiphytes depend on other plants to get closer to sunlight, which epiphytes use to make their own food.
- Epiphytes don't need soil to grow. They draw water and nutrients from the air. (Fact: epiphytic orchids' aerial roots and leaves absorb nutrients and moisture brought by rain, mist, and other organisms. Epiphytic bromeliads have special leaf scales that absorb water.)

Take your students to World Deserts. Have them observe the different cacti. Students should choose one cactus to draw in their Journal. A desert typically receives less than 10 inches of rain a year. Contrast this with the jungle which receives more than 70 inches of rain a year.



Student Discovery Journal page

Think Tank Prompt: Why do cacti look the way they do? How do they get water? How do they get nutrients? Focus student attention on the cacti skin and stems.



Have students write about how cacti survive in the desert heat. Samples include:

- Cacti can retain moisture in their tissues and remain succulent for long periods of time because of their waxy skin.
- Cacti have roots that are close to the surface of the ground to help them absorb water and nutrients, taking advantage of even the smallest amounts of rainfall.

Tell students they can add ideas as they progress through their Student Discovery Journals and learn more about plant life, adaptation, and survival.



What Did You Learn?

Discussion Prompt: Consider the following statement: “Plants are like humans because both need energy to survive. However, plants are different because they capture energy from the sun and make their own food.” Is this statement true or false? Why? Students should use information from their observations and explorations to support their responses.



Big Idea 2

A Puzzle of Plant Parts

Why do plants have so many different parts?

Student Objectives

Upon completing this Journal section, the student will be better able to:

1. Explain the structure and function of different plant parts.
2. Use observational skills to theorize how the designs of distinct plant parts help plants adapt to and survive in their habitats.
3. Synthesize knowledge about the structure and function of different plant parts.

Time Needed: 45 minutes

Exploring the Conservatory...

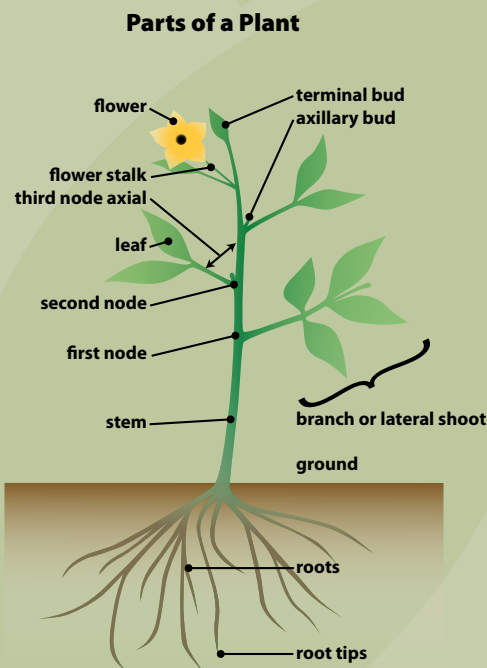
Discussion Prompt:

Look at the accompanying drawing of plant parts. Ask your students to name the major plant parts. What are the jobs of each part? See plant parts diagram below.

Puzzle Piece #1 STEMS!

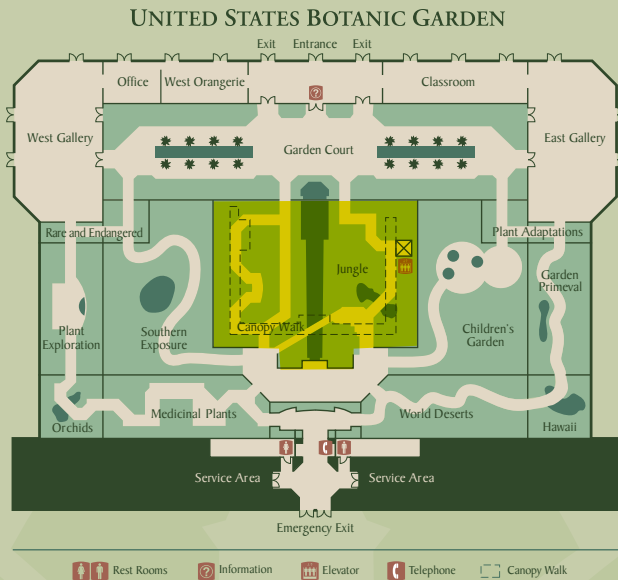
Whatever room you begin in, have your students identify the stems on plants and draw the stem of the plant they choose. *Discussion Prompt:* What would happen to a plant if it did not have a stem?

The stem holds up the leaves and flowers of a plant. This is important because the leaves need to be held up to the sun to get light for photosynthesis and the flowers need to be held up to be available for pollination. Stems carry water and minerals up from the roots to the leaves to help with photosynthesis and take food back down to be stored.



Become a Savvy Plant Sleuth!

If you are not already in the Jungle, bring your students into the Jungle.



Puzzle Piece #2 LEAVES!

Ask students to find and draw two different kinds of leaves displayed in the Jungle, one from the ground floor and one from the canopy. The leaves they choose should be completely different in size, shape, texture, and color.

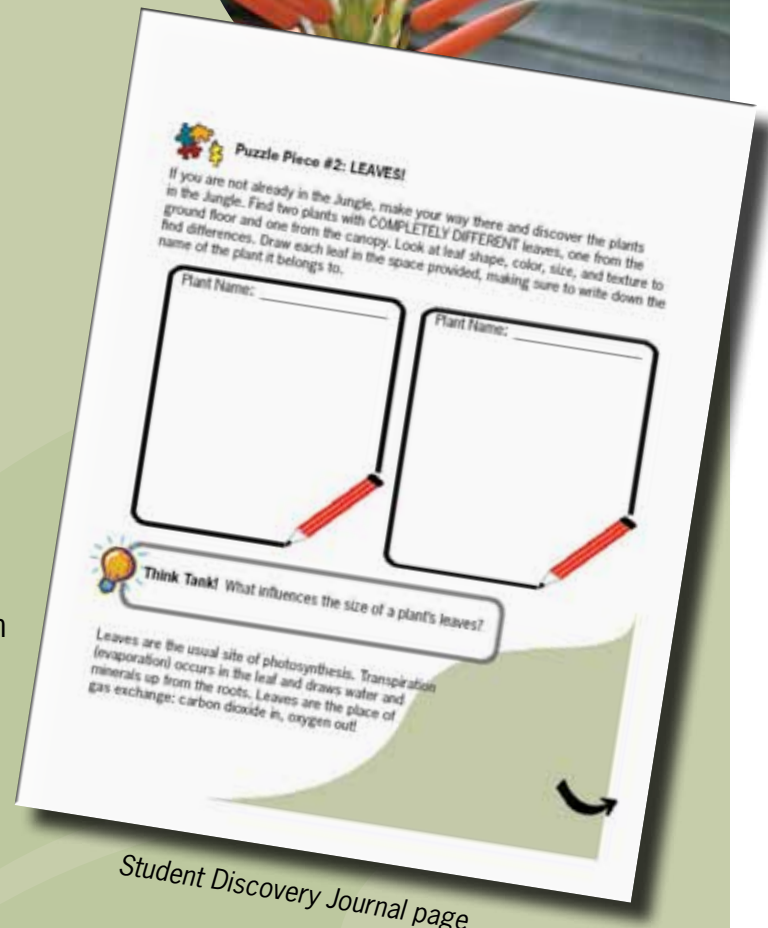
Think Tank Prompt: What factors seem to influence the size of the plant's leaves?

Facts for discussion:

- Many plants found in the understory of tropical forests (i.e., in the shade of large trees) usually have large leaves to catch the sunlight that falls through the forest canopy. Even though they live in a tropical environment with a lot of light, there is tremendous competition for light because of the dense plant growth. As a result, leaves are usually large to serve as good "solar panels." The higher one gets in the jungle, the smaller the leaf.
- Plants in the desert usually have very small or reduced leaf surfaces. They don't need to compete for light because there is a lot of light available and fewer plants to compete with. Instead, the adaptive pressure is to avoid water loss. In fact, some desert plants have no leaves. See if your students can find one. How do they think the plant captures the sun's energy?

Photosynthesis Refresher:

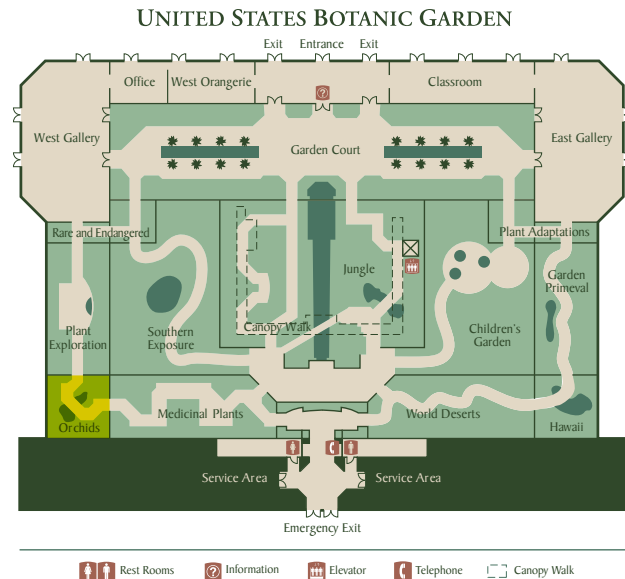
The process by which a plant uses sunlight, water, and carbon dioxide to produce oxygen and sugar (food).



Leaves are the usual site of photosynthesis. Transpiration (evaporation) occurs in the leaf and draws water and minerals up from the roots. Leaves are the place of gas exchange: carbon dioxide in, oxygen out! Other plant parts that are green may contain chlorophyll, the pigment necessary for photosynthesis to occur. In many desert plants, photosynthesis mostly occurs in the stems.

Puzzle Piece #3 ROOTS!

Proceed to Orchids.



Ask students to find a plant that does not have underground roots. Students should sketch both the plant and its surrounding habitat in the space provided in their Student Discovery Journals.

Think Tank Prompt: As students sketch, ask: Why do you think these plants have roots above ground? What purpose do they serve? In which environment are they most likely to thrive?

Facts for discussion:

- Epiphytic orchids grow on other plants. This is an adaptation to life in the tropical forest, where the climate is warm and moist; the air never freezes, and light is scarce below the canopy. These plants find a perch on other plants above ground level to find more favorable conditions, but they are not parasitic. These orchids' aerial roots and leaves absorb nutrients and moisture brought by rain, mist, and other organisms. Some orchids shed their leaves, and the roots of these plants contain the chlorophyll required for photosynthesis.
- Roots absorb water and nutrients. Roots help anchor the plant. Roots also can act as 'storage closets' for the sugars and starches the plant will need for future growth.

Have your students speculate on how they would differ in appearance if roots were to specialize on only one of these three functions (absorption, anchoring, or storage).

Puzzle Piece #4 FLOWERS!

Have students examine the orchids. Prompt students to draw their favorite orchid flower in the space provided in the Student Discovery Journal.

Think Tank Prompt: What was the reason for their flower choice? What is the purpose of a flower for a plant?

Fact for discussion:

Flowers advertise a plant to pollinators. Some use bright color, scent, or patterns to entice insects and birds to interact with the flower and increase chances for pollination.

Dig Deeper...

Make your way to the Garden Court. Through investigations of the Garden Court plants, students should complete the following chart found in their Student Discovery Journal (Sample answers provided).

1. Find a plant that humans depend on for something they drink. Which part of the plant is used in this drink?

Plant: coffee plant Product: coffee Plant Part: seed (berries)

Other choices: Tea plant (tea made from leaves), Cocoa (cocoa from the seed for chocolate milk)



2. Find and list below two plants with parts that are used to season and flavor foods and/or drinks.

What part of that plant do you use?

Plant: Allspice Usable Part: berries

Plant: Vanilla Usable Part: seeds

Other choices: grapefruit (fruit), tarragon (leaves), cinnamon (bark)

3. Look at the large murals. (There are six murals along the north walls of the Garden Court.) Find a plant that is used to make a product that is not a food or a beverage. What part of the plant does this item come from?

Plant: cotton Product: T-shirt Plant Part: seed



What Did You Learn?


Discussion Prompt: "Plants and humans are both alive, but they function differently to allow them to cope with the challenges in their environments." Is this statement true or false? Why? Have students support their answers with evidence from their journal work and explorations.

Just for Fun: Why don't plants have teeth?

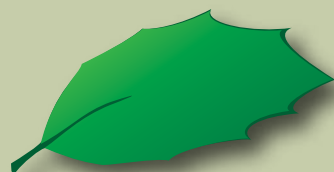
Dig Deeper...
Follow your teacher or chaperone back to the Garden Court. Use your knowledge of plant parts to explore the Garden Court and answer the following questions:

1. Find a plant that humans depend on for something they drink. Which part of the plant is used in this drink?
Plant: _____
Product: _____
Plant Part: _____
2. Find and list below two plants with parts that are used to season and flavor foods and/or drinks. What part of that plant do you use?
Plant: _____
Plant Part: _____
Plant: _____
Plant Part: _____
3. Look at the large murals. Find a plant that is used to make a product that is not a food or a beverage. What part of the plant does this item come from?
Plant: _____
Product: _____
Plant Part: _____

What Did You Learn?
Plants and humans are both alive, but they function differently to allow them to cope with the challenges in their environments. Is this statement true or false? Why?



Student Discovery Journal page



Big Idea 3

Surviving Against the Odds

How do plants adapt and survive?

Student Objectives

Upon completing this Journal section, the student will be better able to:

1. List different ways plants adapt to their environment.
2. Use observational skills to evaluate plant adaptations for different environments and outcomes.
3. Synthesize knowledge about plant adaptations.

Time Needed: One hour

Exploring the Conservatory...

Think Tank Prompt: What does it mean to adapt? Why do plants need adaptations? What are some examples of different plant adaptations?

Here are some adaptations:

- *Physical adaptations:* drip tips on leaves of jungle plants to direct water away from the plant, sharp spikes that make plants difficult and painful to eat, accordion-like stems that can expand to store water
- *Growth patterns:* stems that reach toward the light, big leaves to catch the light, spines that protect, hair to protect from sun
- *Physiological adaptations:* trees release compounds to heal wounds, plants scents to attract pollinators, bitter leaves to discourage feeding animals
- *Partnerships between plants and animals:* Flowers look like insects (varying size, shape, and color) to attract their pollinator

Have your students list examples of each type of adaptation in their Student Discovery Journal.

Discussion Prompt: Which adaptation do you find most interesting? Why?

Become a Savvy Plant Sleuth!

Beginning in the Jungle, take your students on a Scavenger Hunt through the Conservatory.

Pre-Scavenger Hunt Think Tank Prompt: “Plants only have so much energy so they need to make good use of it. Adaptations take energy and time to evolve and each one of these characteristics has a specific function that is beneficial to the plant.” Have students brainstorm one or two possible adaptations and their functions. (Possible adaptations include fragrance, color, specialized structures [pitcher plants, seeds that float], or fleshy, edible fruit and berries.)



Have your students find the following adaptive traits:

1. Leaves that appear to be already chewed

Plant: Window Leaf (vine) [a.k.a. Swiss Cheese Plant]

Suggested Locations at USBG: Jungle

2. Aerial roots

Plant: Epiphytes (orchids)

Suggested Locations at USBG: Orchids or Jungle

3. Two different plants that thrive in a very wet environment

Plant: Satin Leaf, Capote (Arum Family)

Suggested Locations at USBG: Jungle

4. A plant that appears to depend upon another for survival

Plant: Bromeliad, vines, orchids

Suggested Locations at USBG: Orchids, Plant Adaptations, or Jungle

5. Looks like it could stop herbivores from eating it

Plant: Silk Floss Tree, Acacia Tree, cacti

Suggested Locations at USBG: Plant Adaptations, Rare & Endangered Species, World Deserts, or Garden Court.

6. A plant that has characteristics to help protect it from the hot sun

Plant: cacti

Suggested Locations at USBG: Rare and Endangered Species or World Deserts.

Make your way to the Jungle. Work with your group to brainstorm one or two adaptations a plant may want to have in the jungle. Why would the plant want to use its energy to have the adaptation(s) you choose? List your reasons below.

1. _____
2. _____
3. _____

The U. S. Botanic Garden would like your help in charting different plant adaptations in our Conservatory. Follow your teacher or chaperone on a Scavenger Hunt and fill in the chart on this page.

Adaptive Traits:

1. Leaves that appear to be already chewed
Plant: _____ Country of Origin: _____
Why You Chose It: _____

2. Aerial roots
Plant: _____ Country of Origin: _____
Why You Chose It: _____

3. Two different plants that thrive in a very wet environment
Plant: _____ Country of Origin: _____
Why You Chose It: _____

4. A plant that appears to depend on another plant for survival
Plant: _____ Country of Origin: _____
Why You Chose It: _____

5. Looks like it could stop herbivores from eating it
Plant: _____ Country of Origin: _____
Why You Chose It: _____

6. A plant that has characteristics to help protect it from the hot sun
Plant: _____ Country of Origin: _____
Why You Chose It: _____

Student Discovery Journal page

Additional Information/Examples about each Adaptive Trait:

1. A plant with leaves that appear to be chewed: Window Leaf (vine) [a.k.a. Swiss Cheese Plant].

Why would a plant grow this way?

- To deter predators, some plants have leaves with holes that appear to have been already eaten.

2. Plants with aerial roots: Epiphytes (orchids)

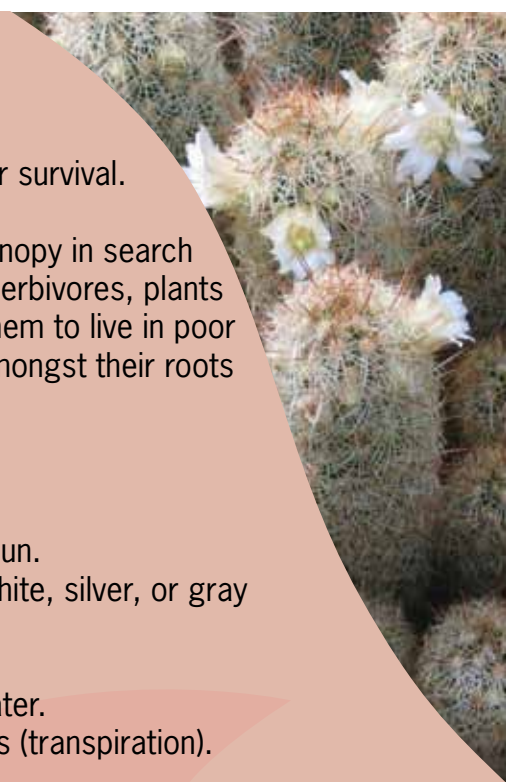
How do these roots help the plant survive in its environment?

- Aerial roots are roots that form and remain above ground.
- Generally help to stabilize the plant in addition to absorbing water and nutrients.
- Can allow the plant to climb, increase absorption, and/or exchange nutrients and gases.

3. Plants with leaves made to thrive in a very rainy environment: Why do these adaptations work?

- Many plants in rainforests or jungle environments have elliptical leaves with elongated “drip tips” that shed excess water.
- Channeled midribs that act as “gutters” for drainage.
- Waxy leaves that allow water to run off (like a freshly waxed car!).

4. A plant that appears to depend upon another plant or animal for survival.
 - Bromeliads and orchids live in the treetops of the rainforest.
 - Vines use trees as support so they can climb high into the canopy in search of sunlight. (Plants that depend on ants for protection from herbivores, plants that trap and digest insects to get extra nitrogen, allowing them to live in poor soils, and plants that depend on fungi or bacteria that live amongst their roots for extra nutrition in poor soils).
5. A plant that looks like it could stop herbivores from eating it:
 - Acacia Tree, or cacti, which possess spines, Silk Floss Tree.
6. A plant that has characteristics to help protect it from the hot sun.
 - Cacti possess thick, juicy stems that can store water often white, silver, or gray with hairs or velvety fuzz – act as light reflectors.
 - Thick succulent stems.
 - Thorns and spines to keep herbivores from accessing this water.
 - Reduced leaf surface – often very lacy – to prevent water loss (transpiration).

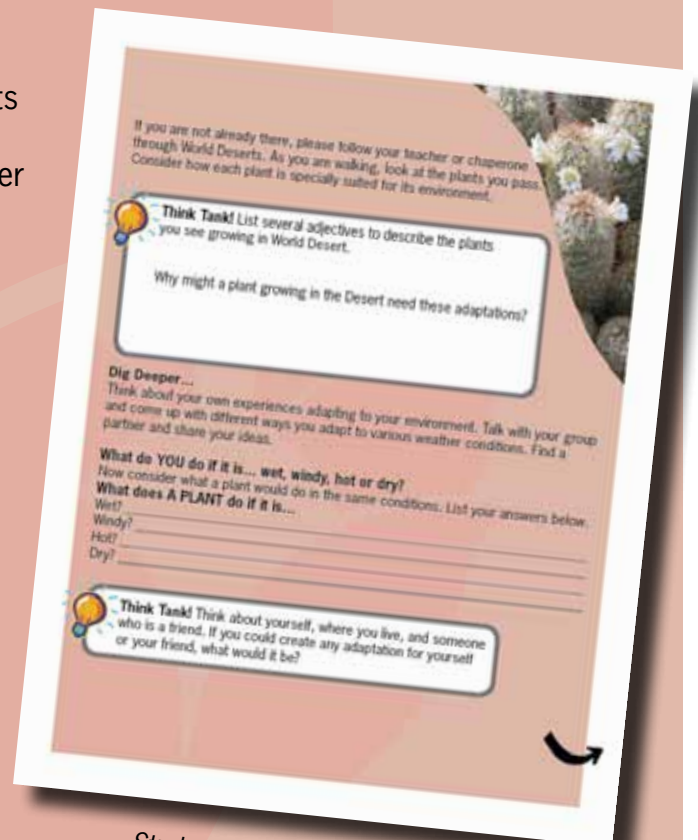


The Scavenger Hunt should conclude in World Deserts.

Think Tank Prompt: List several adjectives to describe the plants you see growing in world Desert

Facts for discussion:

- Some plants have thicker, waxy leaves; some plants have thorns.
- Aloe and jade have waxy coatings that prevent water loss (transpiration).
- Many desert plants have small leaves or spines in place of leaves.
- Some cacti are covered with what appear to be white hairs, which help reflect the hot desert sun.
- Thorns help to deter animal predators that are seeking the water stored in the spongy leaves and stems.



Student Discovery Journal page

Dig Deeper...

Have your students reflect on their own experiences adapting to their environment. How do they cope with challenges in their environments?

Chart Activity: What do you do if it is...

- Wet? (Sample answers: umbrella, rain coat, bathing suit)
- Windy? (Sample answers: windbreaker, scarf)
- Hot? (Sample answers: go swimming, sit in the shade)
- Dry? (Sample answers: drink, wear chapstick, put on lotion)

Have students repeat the process considering the life of a plant.

Chart Activity: What does a plant do if it is...

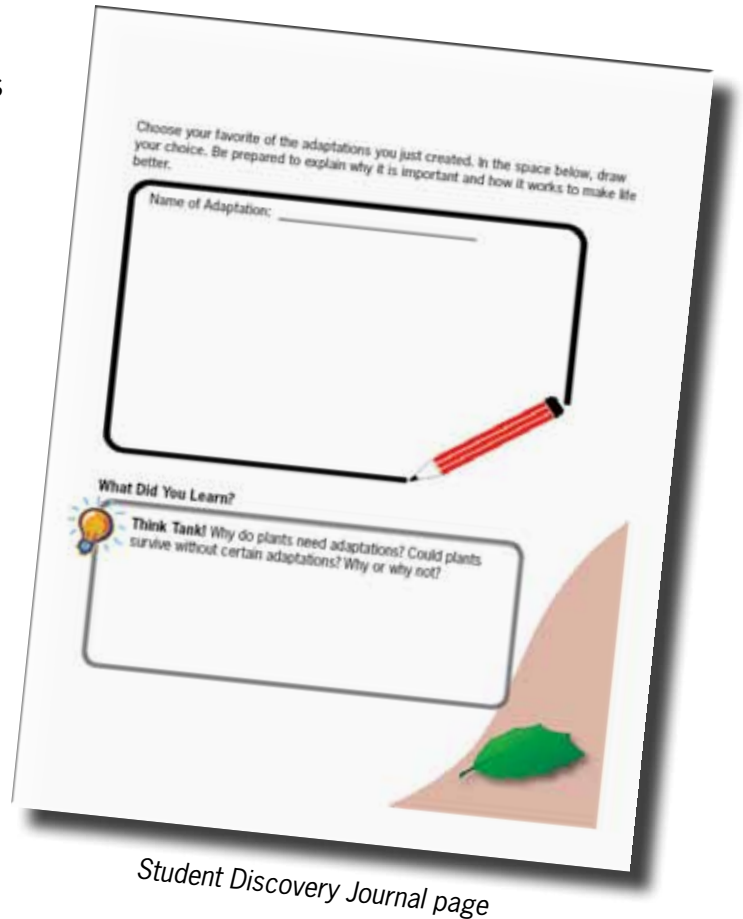
- Wet? (Sample answers: leaves designed for water drainage)
- Windy? (Sample answers: pollinators that are blown around, spines to deflect wind)
- Hot? (Sample answers: thick waxy skin to conserve water, little or no leaves)
- Dry? (Sample answers: losing leaves when dry)

Think Tank Prompt: Think about yourself, where you live, and someone who is a friend. If you could create any adaptation for yourself or your friend, what would it be?

Challenge students to create an adaptation for themselves or a friend. Ask them to draw it, explain why it is important, and how it works.

What Did You Learn?

Think Tank Prompt: How do adaptations help a plant survive? What would happen if plants could not adapt? What adaptations have we seen?



Student Discovery Journal page



Big Idea 4

Plant Multiplication

How do plants reproduce?

Take your students to Garden Primeval.

Student Objectives

Upon completing this Journal section, the student will be better able to:

1. Explain the reproductive strategies of four recognized plant groups.
2. Use observational skills to evaluate reproductive strategies of various plant groups.
3. Synthesize knowledge of plant reproductive strategies.

Time Needed: One hour

Exploring the Conservatory...

Plants can be divided into five recognized groups depending upon their structure and reproduction strategy. The five major plant groups are:

- modern green algae
- ferns (reproduce by spores not seeds)
- mosses (reproduce by spores not seeds)
- gymnosperms (cone-bearing plants with seeds)
- angiosperms (flower-bearing plants with seeds)

The reproduction strategies employed by these different plant groups have changed throughout time and are good indicators of how plants have adapted to environmental stresses that lead to evolutionary change.

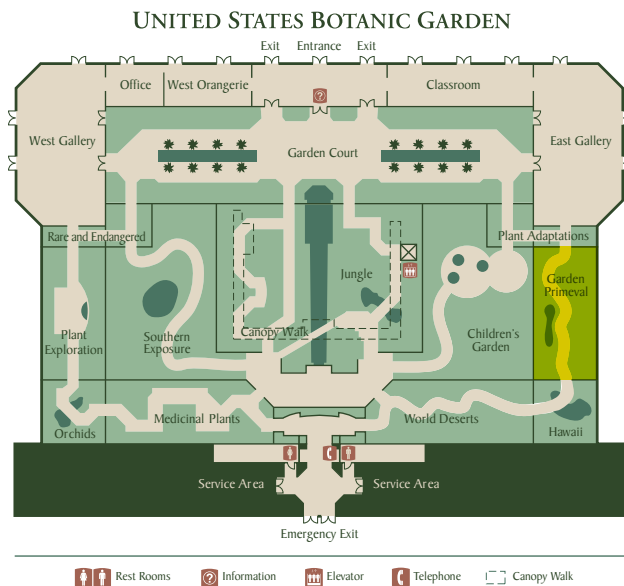
Each student should be assigned one of the following plant groups: fern, moss, gymnosperm, or angiosperm. Have your students draw what they think is an example from their plant group (Note: these four plant groups can be found in Garden Primeval and Plant Adaptations). Take a moment to have your students share their findings.

Without Seeds { Mosses - non-vascular
Ferns - vascular

With seeds { Gymnosperms - with cones
Angiosperms - with flowers

Non-vascular plants: These plants lack an internal means for water transportation.





Allow students to explore the various plants in Garden Primeval.

Discussion Prompt: Which plant groups are represented in this section of the Conservatory?
(Answer: gymnosperms, ferns & mosses)

Have students examine ferns for sori (brown dots containing sporangia on the underside of the fern leaves). Compare how they look on different kinds of ferns.

Have students look for cone-bearing plants (hint: the two tall trees and the large cycads are easy to find), observing as many cones as they can, comparing their similarities and differences (size, color, structure, placement, etc.).

See if students can find moss in the sporophyte stage (sporangia are $\frac{1}{4}$ to $\frac{1}{2}$ inch tall).

Facts for discussion:

- A plant has two life stages: a sporophyte and a gametophyte. The sporophyte is diploid ($2n$) and it has organs (sporangia) that produce spores that are haploid ($1n$). Each spore grows into a gametophyte plant that produces eggs and sperm (each $1n$); eggs and sperm unite and grow into a new sporophyte ($2n$). This is the standard plan for plant reproduction and is called the "alternation of generations." Most plants familiar to us are in the sporophyte stage, but some groups, the gametophyte is the larger, more familiar plant.



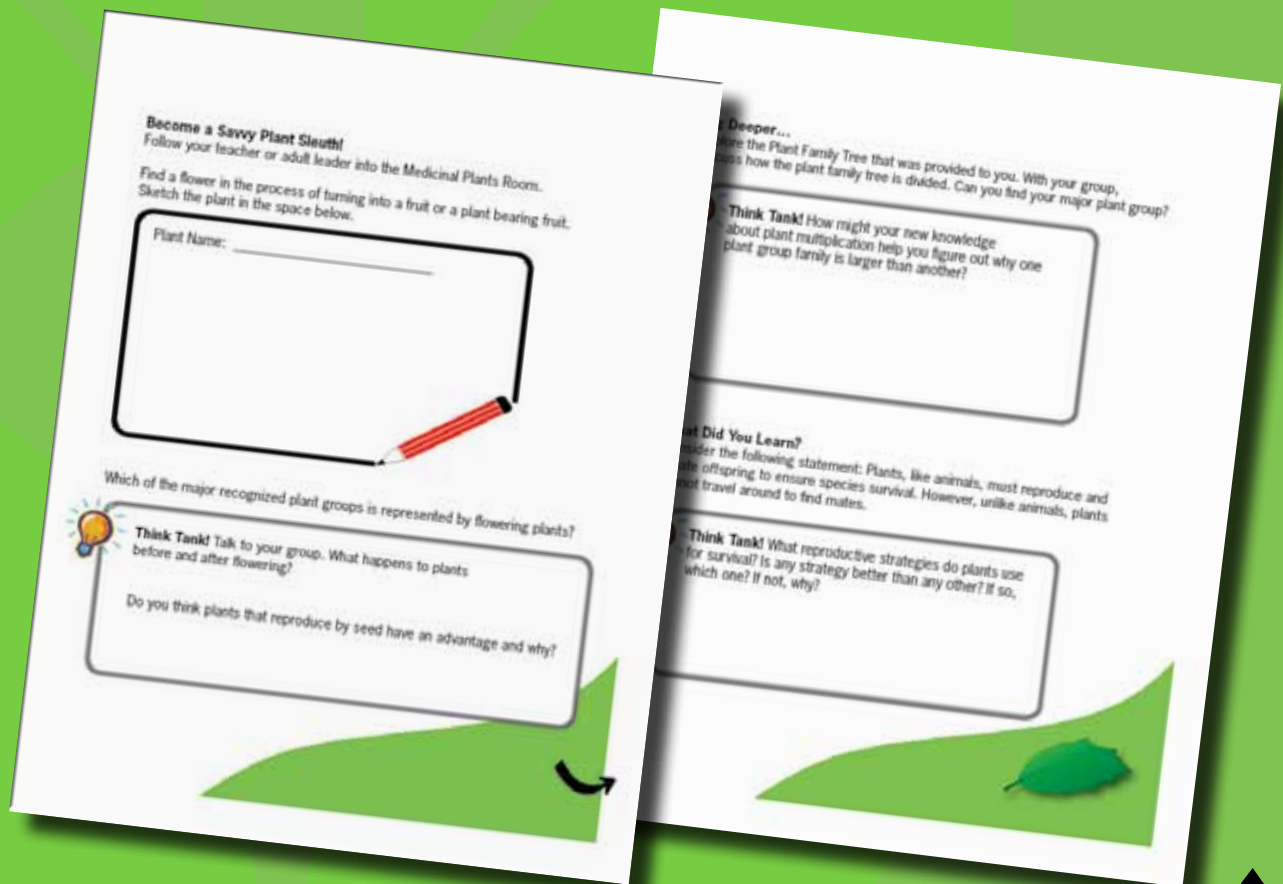
moss with sporophytes

in

- The fern we recognize is in the sporophyte stage; it includes the frond, a stem, and exterior roots. The frond first appears as a 'fiddlehead' and then unfurls to reveal the leaf blades. When the blade matures, small, circular, rust-colored patches may be found on the underside of some leaves. These are sori (singular; sorus), each contain a cluster of sporangia which release spores into the wind for dispersal. They will grow into tiny free living gametophytes.
- The familiar carpet-like moss is the gametophyte (haploid) stage. It produces egg and sperm that unite to grow a tiny sporophyte (diploid) that looks like a stalk and capsule emerging from the carpet of moss, each of which will grow a new moss plant (haploid).
- The gymnosperms, or cone bearing plants are in the sporophyte stage. They produce male and female cones that contain tiny gametophyte plants (that we don't see). Pollen released from the male cone fertilizes the eggs in the female cone and seeds are produced.

If they haven't already seen it, have students find the dinosaur.

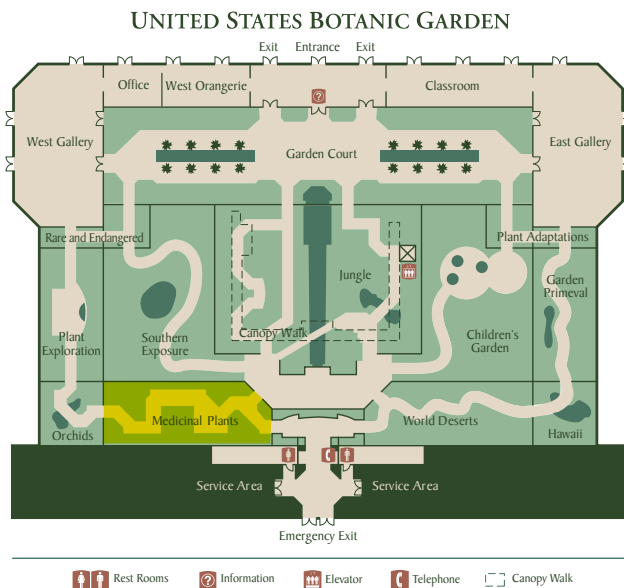
Think Tank Prompt: How did ferns and mosses survive while the dinosaurs became extinct?



Student Discovery Journal pages

Become a Savvy Plant Sleuth!

Take your students into Medicinal Plants.



Student Discovery Journal page

Have your students find a flower in the process of turning into a fruit. (Seek out the pepper plants and papaya). If it isn't possible to find a flower in the process of becoming a fruit, have students find a plant with fruit and talk about the process of going from flower to fruit.

Students should sketch their selection. Which of the five recognized plant groups is represented in the Medicinal House? How do you know?

Think Tank Prompt: What happens to this plant before and after flowering? Seeds have both a protective coating and a built-in food source, allowing them time to wait for favorable growing conditions.

Facts for discussion:

- The flower is fertilized and then produces a seed and a fruit. Look carefully.
- After a flower is pollinated, the job of the petals and sepals is done and the plant allows these floral parts to die and fall off.
- On many fruits, you can see the dried remains of the sepals (e.g., an apple – close examination of an apple should reveal the dried sepals at the “bottom” of the fruit).
- The resulting fruit may play an important role in seed dispersal depending upon what kind of plant it is.

Dig Deeper...

Take out the Plant Family Tree. Observe how different reproductive strategies help determine where plants are located on the tree.

Think Tank Prompt: Looking at the Plant Family Tree, which plant group is the largest? How does your knowledge of plant reproduction help you determine why one plant group family might be larger than another?

What Did You Learn?

Discussion Prompt: Plants, like animals, must reproduce and create offspring to ensure species survival. However, unlike animals, plants cannot travel around to find mates. What reproductive strategies do plants use for survival (wind, water, insects, animals, humans)? Which do you think is the most effective? Why?





Review: What Have You Learned?

Concluding the trip: What have students learned today? What are the important take home messages? Consider what to expand upon back in the classroom.

Big Idea 1: Are Plants Like Us?

Plants, like humans, need energy to survive. However, plants are different from us because they capture energy from the sun and make their own food. Humans must eat their food.

Big Idea 2: A Puzzle of Plant Parts

Unlike humans, plants have a number of parts (roots, stems, leaves, flowers, and seeds) that work together to make food. The plants harvest energy from the sun and utilize water and nutrients from the soil to ensure survival where they grow, though may look very different from one plant to another. Humans don't have any of these parts.

Big Idea 3: Surviving Against the Odds

If humans are cold they put on sweaters to fight off a chill. Plants also employ adaptive strategies to adjust to their environment. Plants have evolved to look the way they do to thrive in local temperature, light, moisture, and soil type conditions.

Big Idea 4: Plant Multiplication

To ensure species survival, plants, like humans, must reproduce and create offspring. Unlike humans, plants cannot travel around to find their mates or places to live. Instead plants depend on wind, water, and other factors, such as animals, to disperse their pollen, seeds, and spores.



